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Geologic and Molluscan Evidence for a Previously Misunderstood Late Pleistocene, Cool Water, Open Coast Terrace at Newport Bay, Southern California

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Abstract. A macro-invertebrate fauna from a 7 m elevation terrace remnant on the front of the Newport Mesa contains 63 mollusks, 58 specifically identified. These taxa represent a mixed death assemblage similar to that seen on rocky terrace platforms at intertidal depths in southern to central California today. The extralimital northern bivalve *Macoma inquinata* (Carpenter) and gastropods *Tectura* sp., cf. *T. persona* (Rathke), and *Tegula montereyi* (Kiener) suggest slightly cooler water temperatures than present today. These extralimital cool-water taxa, along with the terrace's geomorphic position in the palisades along the front of Newport Mesa, below other mapped terraces, separate it from the well known first terrace and its associated warm-water fauna recognized by previous authors, and suggest a younger age than the first terrace around Newport Bay.

INTRODUCTION

A poorly exposed terrace platform remnant and shoreline angle are preserved at an elevation of about 7 m above sea level in the sea cliffs along the Pacific Coast Highway, north of Newport Bay, Orange County, California (Figure 1). This paper describes the terrace remnant and its fauna, which is distinct from previously reported late Pleistocene faunas around Newport Bay.

The molluscan fauna reported here differs from the well known faunas on the higher, more extensive "first" terrace around Newport Bay (Bruff, 1946; Kanakoff & Emerson, 1959; Peska, 1975, 1976; Mount, 1981), by containing taxa that now live in cooler water than present locally today. This is unlike the fauna from the first terrace, which contains taxa suggesting water temperatures the same or warmer than exist currently along the Orange County coast.

Some specimens examined for this study were collected by the author and are housed in the Geology Department, University of California, Riverside. In addition, specimens from Bruff's collection (housed at the Museum of Paleontology, University of California, Berkeley), and specimens from the Watts collection (housed at the Department of Invertebrate Zoology and Geology, California Academy of Sciences) were also examined.

The following abbreviations are used here: CAS—California Academy of Sciences, Department of Invertebrate Zoology and Geology; UCMP—University of California, Berkeley, Museum of Paleontology; UCR—University of California, Riverside.

PREVIOUS STUDIES

Fossil mollusks have been collected from the Newport Bay area for over 100 years (Watts, 1900; Arnold, 1903). Both Watts (1900) and Arnold (1903) referred to fossils that probably came from the terrace remnant discussed here. Watts (1900:61) referred to fossils from "... one mile north of Newport ..." in "... dry oil-sand 2′ in thickness ... interbedded with the shale," and later (p. 223) listed 14 taxa referred from two localities from "upper oil-sand and sandstone ... West side of inner bay, Newport, Orange County." These collections are likely to have come from the terrace remnant discussed here because of the tar-impregnation of the fossils, which occurs from this terrace remnant and have not been observed or reported elsewhere in the Newport Bay area. Also Watts (1900) showed oil-sand exposed only in the vicinity of the terrace remnant discussed here. Arnold (1903) listed 21 molluscan taxa from two localities at Newport, citing Watts (1900), one of whose localities is here referred to the terrace remnant. Later, Bruff (1946) produced a detailed account of the Pleistocene geology and fossil mollusks at Newport Bay. He listed 162 species from 12 localities around the bay. Bruff's (1946) locality, UCMP A-3132, is on the terrace remnant, but was not recognized as distinct from other faunas around the bay. Hoskins (1957) reported fossil mollusks from three localities at Newport Bay, but all these localities are from the higher first terrace of Vedder et al. (1957) and contain extralimital warm-water taxa. By far, the most detailed work on late Pleistocene faunas around Newport Bay is that of Kanakoff & Emerson (1959) who listed nearly 500 invertebrate taxa from three localities, all from the first terrace around Newport Bay; all three of Kanakoff & Emerson's (1959) sites contain extralimital warm water taxa. Peska (1975) and Mount (1981) described an extensive fauna from the first terrace from a road cut on the south-

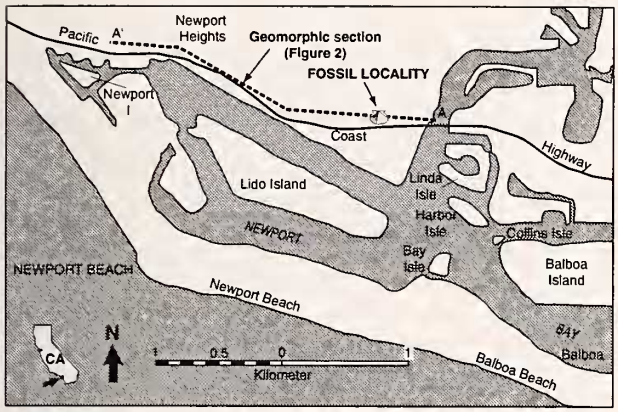


Figure 1. Index map showing location of fossil locality on terrace remnant along the palisades of Newport Mesa in Newport Heights, Orange County, California.

west extension of the Newport Freeway on the north side of Newport Mesa. This fauna contains extralimital warm-water faunal elements, including the gastropods *Eupleura muriciformis* (Broderip, 1833), *Pterynotus leeanus* (Dall, 1890), and the bivalves *Anadara perlabiata* (Grant & Gale, 1931), *Chione gnidia* (Broderip & Sowerby, 1829), and *Trachycardium panamense* (Sowerby, 1833) [as *T. procerum* (Sowerby, 1833)], among others. Peska (1976) described a similar paleoenvironment with pholad clams boring into a hard bedrock and terrace sediments overlying these deposits attributed to the first terrace because of extralimital southern molluscan taxa.

GEOLOGY AND STRATIGRAPHY

Geomorphically the terrace remnant is located on the front of the palisades that make up Newport Mesa below the top of the bluff which has been mapped as the first terrace by Vedder et al. (1957) (Figure 2). The shoreline angle of the terrace remnant discussed here is present though not observable. This conclusion is based on the outcrop pattern of the Miocene Monterey Formation both below and above the terrace platform. Faulting of the terrace remnant into place from the higher terrace is not feasible because it would not fit the outcrop picture of the Monterey Formation (Figure 2) and there is no evidence for faulting along the front of the bluffs. Sediments making up the terrace deposits are up to 70 cm thick and are composed of a chaotic mixture of small (2–10 cm), rounded, gneissic cobbles; coarse- to fine-grained, poorly sorted, quartz-rich sand, mollusk fragments, and boulders of Monterey Formation diatomite up to 50 cm in diameter. Infaunal bivalves, including *Platyodon cancellatus* (Conrad, 1837) and pholads bored the Monterey Formation boulders and upper surface of the Monterey platform. Tar then seeped onto the terrace platform from clastic dikes in the Monterey Formation, preserving the terrace platform and immediately overlying sediments. The tar that preserved this terrace remnant originated in the underlying Monterey Formation as shown by heavy mineral analysis by Meek (1928). The geologic relationship of the terrace platform with underlying and overlying sediments is illustrated in Figure 3.

The terrace platform sediments are overlain by 1.5 to 2.5 m of fine-grained, moderately well sorted, cross-bedded, oil-impregnated sand. Because these sediments lack fossils and are moderately well sorted and cross bedded, they are believed to be eolian sands. Above and presumably behind the dune sands is Monterey Formation diatomite, which suggests that the shoreline angle is within a few meters of the terrace platform, and would be expressed in the bluff face, if exposures existed.

Fossil collections from the Newport Bay area referred to the outer Newport Bay terrace remnant reported here

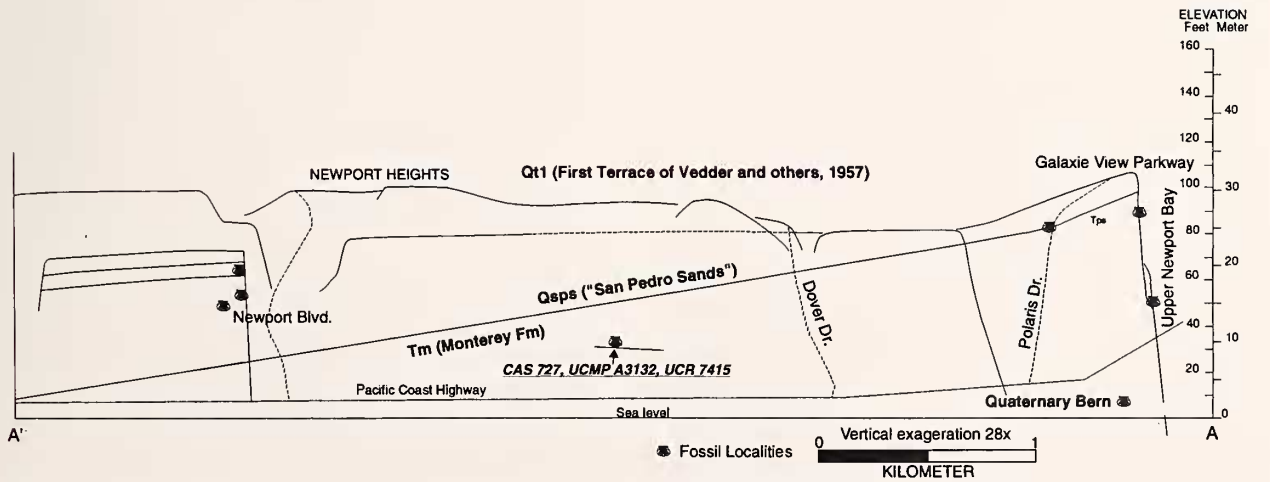


Figure 2. Geomorphic section along the front of the Newport Mesa (S. 76°E), along the Pacific Coast Highway, showing relationship of the first terrace of Vedder et al. (1957), the terrace remnant and fossil locality discussed here, and the Monterey Formation.

Table 1

Pleistocene molluscan taxa from the remnant marine terrace deposit, Newport Bay, Newport Heights, Orange County, Southern California. () = fragments.

Taxa/Localities	UCR 7415	UCMP A3132	CAS 727
Mollusca			
Bivalvia			
Adula diegensis (Dall, 1901)	—	2	—
Chlamys sp., cf. *C. hastata* (Sowerby, 1842)	(5)	1	1
Crassadoma gigantea (Gray, 1825)	(3)	1	—
Cumingia californica Conrad, 1837	13	1	—
Diplodonta orbella (Gould, 1851)	4	1	2
Glans carpenteri (Lamy, 1922)	3	1	—
Kellia suborbicularis (Montagu, 1803)	2	—	—
Leptopecten latiauratus (Conrad, 1837)	1(3)	1	—
Lucinisca nuttallii (Conrad, 1837)	3	—	—
Macoma inquinata (Carpenter, 1864)	1	1	—
M. nasuta (Conrad, 1837)	1(1)	—	—
Mactromeris catilliformis (Contrad, 1837)	1	—	—
Modiolus capax (Contrad, 1837)	1 (1)	—	—
Mytilus californicus Conrad, 1837	—	1	1 as sp.
Ostrea conchaphila (Carpenter, 1857)	1	2	—
Parapholas california Conrad, 1837	3(2)	3	—
Parvilucina sp. indet.	2	—	1
Penitella penita (Conrad, 1837)	5	3	—
Petricola californiensis	3	—	—
P. carditoides (Conrad, 1837)	4	—	—
Platyodon cancellatus (Conrad, 1837)	21	5(10)	3(7)
Pododesmus cepio (Gray, 1850)	1	—	—
Protothaca staminea (Conrad, 1837)	11	7	1(4)
Saxidomus nuttalii Conrad, 1837	1	—	—
Solen? sp. indet.	2	—	—
Tagelus californianus (Conrad, 1837)	—	2	—
Tivela stultorum (Mawe, 1823)	1	—	—
Trachycardium quadragenarium (Conrad, 1837)	(1)	—	—
Gastropoda			
Acanthina spirata (Blainville, 1832)	1	—	—
Agathotoma densilineata Dall, 1921	—	1	—
Alia carinata (Hinds, 1844)	3	8	—
Amphissa versicolor Dall, 1871	3(1)	2	—
Astyris gausapata (Gould, 1850)	—	7	—
Calliostoma canaliculatum (Lightfoot, 1786)	4	2	—
C. ligatum (Gould, 1849)	1(2)	—	—
Conus californicus Reeve, 1844	3	—	—
Crepidula adunca Sowerby, 1825	5	3	1
C. onyx Sowerby, 1824	2	—	—
Crepipatella dorsata (Broderip, 1843)	4	1	—
Diodora aspera (Rathke, 1833)	1	—	—
Discurria insessa (Hinds, 1842)	1	—	—
Fusinus kobelti (Dall, 1877)	4(1)	—	—
Haliotis fulgens Philippi, 1945	3(11)	—	—
Lacuna unifasciata Carpenter, 1857	—	1	—
Lirobittium sp. indet.	—	2	1
Maxwellia gemma (Sowerby, 1879)	(1)	—	—
Mitra idae Melville, 1893	1	—	—
Nassarius sp., cf. *N. cerritensis* (Arnold, 1903)	(1)	—	—
N. fossatus (Gould, 1849)	3	3	4
N. mendicus (Gould, 1849)	4	—	—
N. perpinguis (Hinds, 1844)	2	1	3
Neverita reclusiana (Deshayes, 1839)	2(1)	—	—
Ocenebra sp. indet.	(1)	—	—
Odostomia sp. indet.	2	2	—

Table 1

(Continued)

Taxa Localities	UCR 7415	UCMP A3132	CAS 727
Olivella biplicata (Sowerby, 1825)	30	10	—
O. baetica Carpenter, 1864	2	2	—
Pseudomelatoma torosa (Carpenter, 1865)	1(1)	—	—
Serpulorbis squamigerus (Carpenter, 1857)	7	1	—
Tectura sp., cf. *T. persona* (Rathke, 1833)	1	—	—
Tegula montereyi (Kierner, 1850)			
Polypolacophora			
Callistochiton sp. indet.	1	—	—
Scaphopoda			
Dentalium neohexagonum Pilsbry & Sharp, 1897	1	—	—

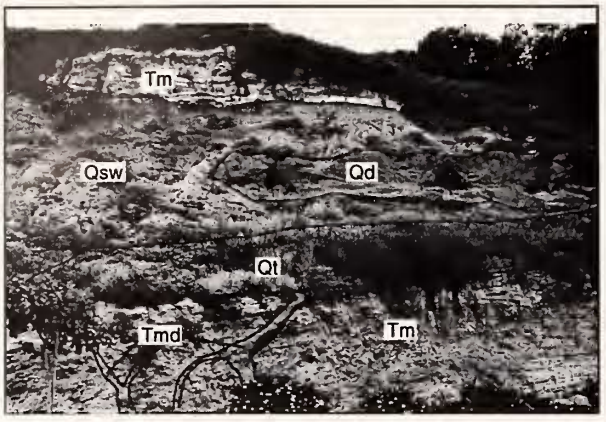
include a collection by W. S. Watts from the old State Mining Bureau collections, now housed at the California Academy of Sciences; University of California Museum of Paleontology locality A-3132 reported by Bruff (1946); and collections from UCR 7415. Watts' locality data is confusing and cannot be exactly placed, but the tar impregnating the fossils (and sediments) in his collection is distinctive and has not been reported (or observed) elsewhere in the Newport Bay area, and the map in Watts (1900) locates his collections in approximately the same locality studied here. Watts' collection does not add any taxa not also reported by Bruff (1946) and herein. Bruff's (1946) collection can be located fairly well as the terrace remnant discussed here in part because the fossils are all tar impregnated, suggesting that they came from the same locality.

PALEOECOLOGY

The fauna from the outer Newport Bay terrace remnant (Table 1) consists of 64 molluscan taxa (32 gastropods, 30 bivalves, one scaphopod, and one chiton). These taxa represent a mixed death assemblage similar to that found on intertidal rocky platforms in Southern California today. In situ taxa represent the exposed rocky shore *Mytilus californianus-Littorina planaxis* community of Valentine (1961) and include the gastropods *Haliotis fulgens, Acanthina spirata, Tectura persona* (questionably identified here), *Diodora aspera,* and the bivalves *Cumingia california; Penitella penita, P. gabbii,* and *Paraplıolas californica.* Valentine's (1961) cold water *Tegula brunnea* (Philippi, 1848) element is represented by the extralimital occurrence of *Tegula montereyi* and *Macoma inquinata.* Other taxa from this mixed death assemblage represent several nearby environments, including kelp forest (e.g., *Calliostoma cancellatum, Discurria insessa, Mitra idae, Tegula montereyi,* and *Leptopecten latiauratus*) and a sandy environment (e.g., *Conus californicus* Reeve, *Nassarius* spp., *Olivella* spp., *Neverita reclusianus, Epilucina californica,* and *Macoma nasuta*). The abundant occurrence of *Olivella biplicata* in this fauna would normally suggest a protected sandy environment (Onuf, 1972), but Valentine (1980) showed that hermit crabs concentrate these shells on rocky terrace platforms.

The molluscan taxa reported here show a maximum overlap of latitudinal range zones at about 34°N, or slightly north of the latitude of the fossil locality (33°N) (Figure 4). Extralimital northern taxa with southern endpoints slightly to the north of the fossil locality include: *Macoma inquinata,* with a modern range from the northern Bering Sea, Alaska south to San Pedro, Los Angeles County, California (Coan, 1971); *Tegula montereyi,* which occurs in California from Bolinas Bay south to Santa Barbara Island off the Santa Barbara coast (Abbott, 1974); and *Tectura persona,* which occurs from the Shumagin Islands, Alaska to Morro Bay, central California (Lindberg, 1981). *Chlamys hastata* (questionably identified here) (Bernard, 1983) and *Calliostoma canaliculatum* (Burch, 1944–1946) have their southern endpoints within one degree of the fossil locality (between 32°N and 34°N). There is one questionably identified southern extralimital taxa. A fragment of a body whorl questionably identified as *Nassarius cerritensis* is present in the collection from UCR 7415. Keen (1971) cited a range for *Nassarius cerritensis* (questionably identified here) including the outer coast of Baja California. Examination of collections at the Los Angeles County Museum of Natural History and the California Academy of Sciences confirms a northern range limit of 30°N. These data, with the exception of *Nassarius cerritensis,* suggest that temperatures may have been slightly cooler during deposition of this terrace platform than exist along the Orange County coast today.

The paleobathymetry determined here, using overlapping depth range data (Figure 5) from living representatives (Bernard, 1983, for the Bivalvia and various sources for the Gastropoda) of the terrace fauna, indicates that deposition occurred between the intertidal zone and about 5 m. Only *Epilucina californica* (30–75 m) and *Lucinisca nuttalli* (10–75 m) are reported from deeper water depths



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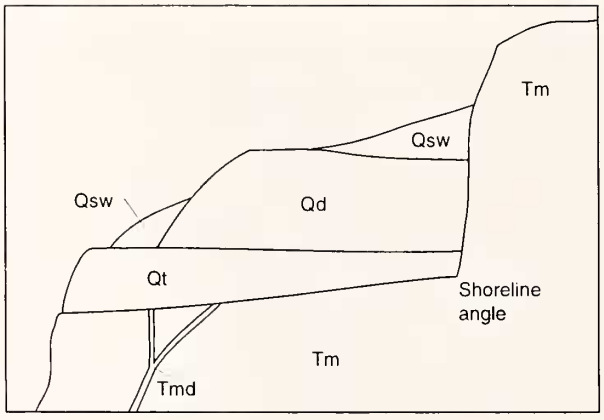

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Figure 3. A. View of the outcrop in 1977; it has since become overgrown with vegetation. Note the Monterey Formation outcropping both below the terrace deposit and above the dune sand and slope wash at the back of the terrace platform. Tm = Tertiary, Monterey Formation; Tmd = Tertiary, Monterey Formation, dike; Qt = Quaternary, terrace deposit; Qd = Quaternary, dune sand; Qsw = Quaternary slope wash. B. Geomorphic cross section showing interpretation of beds observed in outcrop and location of inferred shoreline angle. This illustration is approximately 90° along a vertical axis from Figure 3A.

(Bernard, 1983) in the modern fauna. It is interesting to note that even though the modern depth range of *E. californica,* and to a lesser extent *L. nuttalli,* is outside the intertidal to shallow subtidal depth zone suggested by the rest of the fauna, they are very common constituents of open coast, modern and late Pleistocene terrace platform faunas in Southern California, which otherwise represent intertidal to shallow subtidal depths, and both can be found dead at intertidal depths.

AGE AND CORRELATION

No numerical age determinations have been performed from this terrace remnant. The fauna from the terrace remnant is thought to correlate with the early part of oxygen isotope stage 5 (5a or 5c) (of Shackleton & Opdyke, 1973) because of the cool water extralimital taxa present. Similar cool water faunas reported from the San Pedro area have been correlated with stage 5a and 5c using amino-acid racemization, geomorphic data, and temperature aspects of the fauna (Lajoie et al., 1991; Ponti, 1989; Ponti et al., 1991; unpublished data).

Ongoing research indicates molluscan faunas from older deposits (oxygen-isotope stages 5e, 7, and 9) suggesting warmer water conditions than present along the adjacent coast because of the occurrence of extralimital southern taxa (Powell, unpublished data). It is possible that the fauna here is older than early stage 5 and was subjected to upwelling along the open coast, resulting in a cooler than normal fauna. This may be suggested by the occurrence of *Nassarius cerritensis* in the UCR collection. However, this specimen is represented by a single fragment that is questionably identified (cf.), so it may not be this extralimital taxon or could have been reworked from older Pleistocene deposits around Newport Bay. In either case, it is discounted in interpretations of the paleoenvironment. An age older than stage 9 can be generally ruled out because deposits of this age are generally found at much greater altitudes (see Barrie et al., 1992), and commonly contain extinct taxa (Powell et al., 2000).

Deposits younger than oxygen-isotope stage 5 have not been recognized onshore in the greater Los Angeles Basin, but have been recognized in the Ventura Basin (Lajoie et al., 1982; Yerkes et al., 1987), so their occurrence in the Newport area is possible, though unlikely. Assuming the first terrace represents the stage 5e highstand, as generally accepted (Kennedy et al., 1982), and the terrace remnant represents stage 3, then that would argue for an increase in uplift rates in the last 60 ka than suggested by the first terrace and the nearby San Joaquin Hills (Grant et al., 1999). I do not favor this for the following reasons: (1) based on molluscan faunas from dated sea-level highstands and lowstands, I would expect mollusks from stage 3 deposits to represent cooler water temperatures than suggested here; and (2) uplift rates in the general area as shown by Grant et al. (1999) and Barrie et al. (1992) are not high enough to bring stage 3 deposits above sea level, much less younger deposits. Mollusks from lowstand deposits attributed to oxygen isotope stage 2 have been recognized elsewhere in California (Powell et al., 1992; Powell, 1994) but are found at a depth greater than 100 m, and the biogeographic character of the fauna is much cooler than present. Faunas younger than oxygen-isotope stage 2 are essentially modern in biogeographic character and are found at deep to shallow water depths in the ocean (Powell et al., 1992; Powell et al., 2000).

If the fauna correlates to early oxygen-isotope stage 5 as suggested here, then it most likely was deposited be-

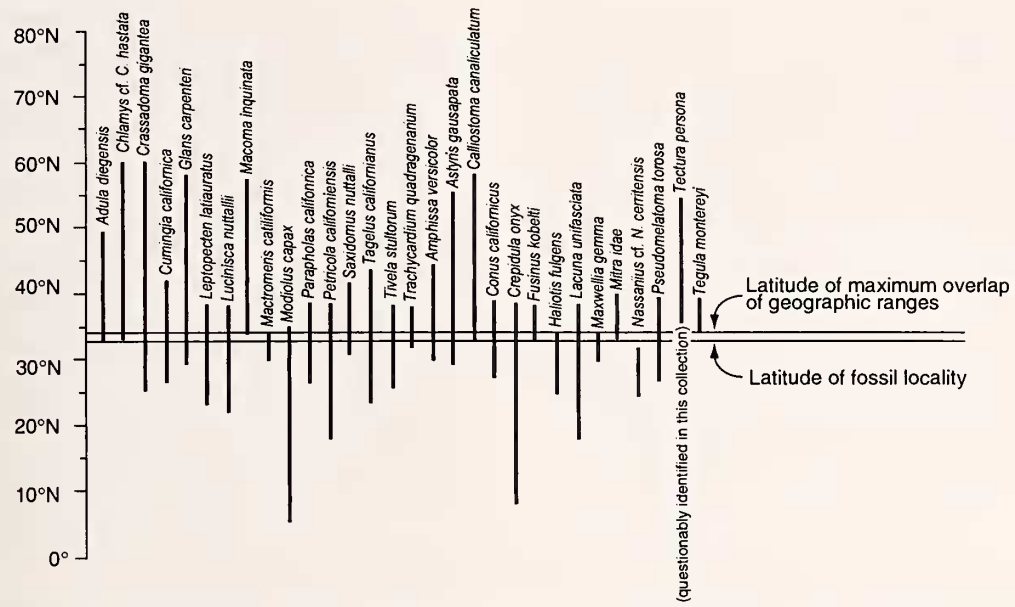

Figure 4. Latitudinal distribution of selected mollusks recovered from the terrace deposit. Data from Bernard (1983), Dall (1921), Keen (1937), Keen (1971), Lindberg (1981, 1988), Marincovich (1977), McLean (1966, 1983), McLean & Gosliner (1996), Morris et al. (1980), and museum collections. The lower line indicates the latitude of the fossil locality. The upper line shows the zone of maximum overlap of mollusk distributions at 34°N, or slightly north of the latitude at which the fossils were collected.

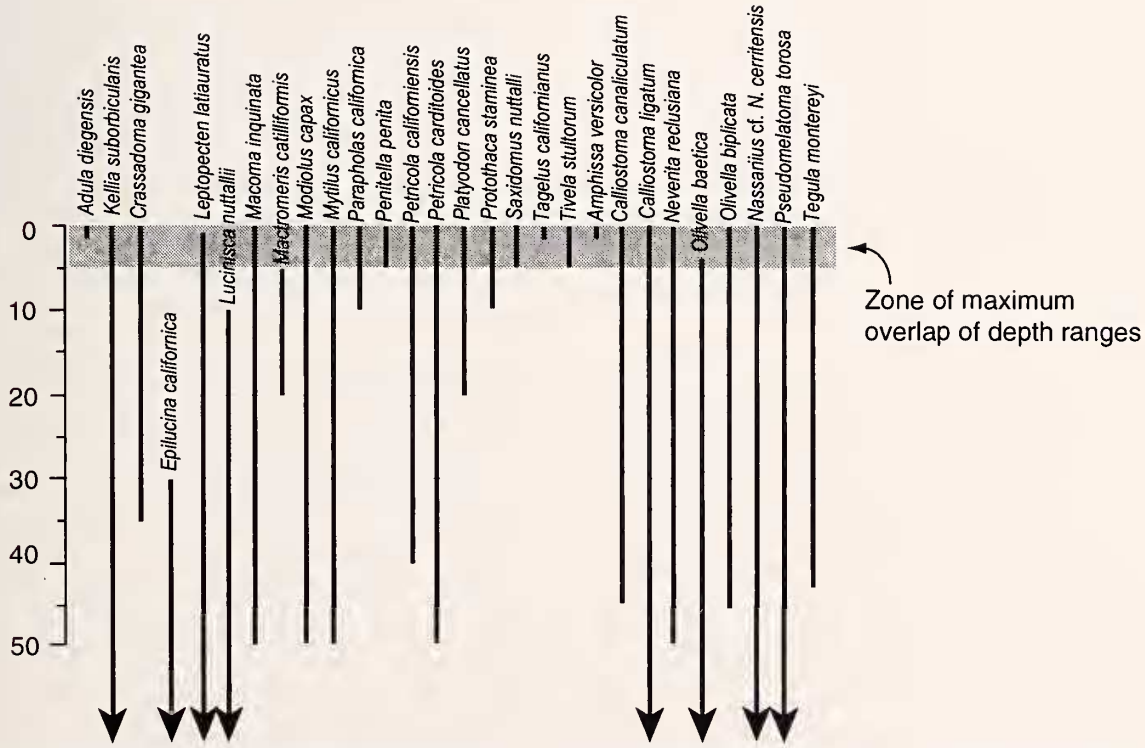

Figure 5. Depth distribution of selected mollusks recovered from the terrace deposit. Data from Bernard (1983), Burch (1944–1946) Groves (1991), Marincovich (1977), McLean & Gosliner (1996), Scott (1998), and museum collections. This figure shows maximum overlap of distributions between the intertidal zone and 5 m, with only *Epilucina californica* (30–75 m) and *Lucinisca nuttalli* (10–75 m) occurring outside that range.

tween 105 ka and 85 ka (Chapell, 1983; Chappell & Shackleton, 1986).

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APPENDIX: LOCALITY DATA

California Academy of Sciences, San Francisco

CAS 727: "Fossil shells from west side of Inner Bay, Newport, Orange County, California. Upper oil sand and sandstone. W. S. Watts collections #9 and #10. From State Mining Bureau Collections. Pliocene."

University of California, Berkeley, Museum of Paleontology

UCB A-3132: Cross-bedded sand with conglomerated saturated oil and fossil fragments. Along face of palisades 1 map inch due south of "S" in Newport Heights, 3.5″ due west of bench mark on top of palisades just above "A" in coast along Pacific Coast Highway. SW1/4, NW1/4, SW1/4, section 27, Newport Beach Quadrangle. Collected by W. Bruff, December 1938.

University of California, Riverside, Department of Geology

UCR 7415: Terrace remnant about 7 m above sea level and extends south for about 160 m, located in bluff behind business and parking lot at 1400 Pacific Coast Highway, Newport Heights, Newport Beach, Orange County, California. 37°31′N, 118°24′15″W. Collected by C. Powell, II, 1971–1978.